U.S. Army, Corps of Engineers Hydropower Analysis Center CENWD-CM-WPX-N

Presentation Overview

I. HAC Function, its Staff, Organization Location and History

II. General Overview of Hydropower Benefit Process

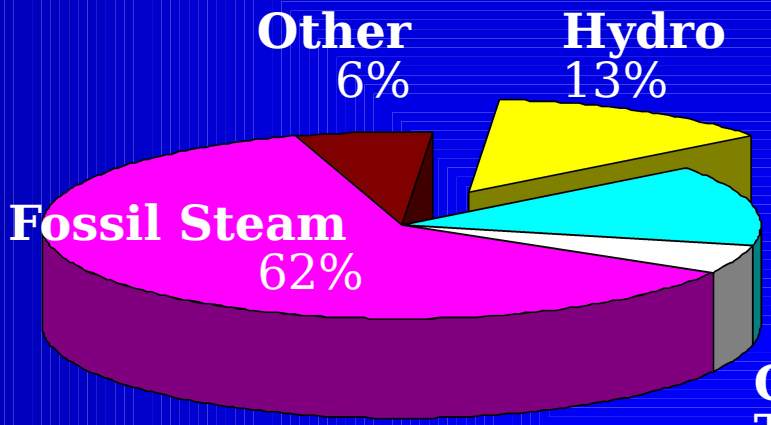
III. Overview of Hydropower Benefit Process Used in Water Supply Studies

IV. Specifics on Hydropower Benefit Process Used in Water Supply Reallocation Studies with Simplistic Illustrative Example

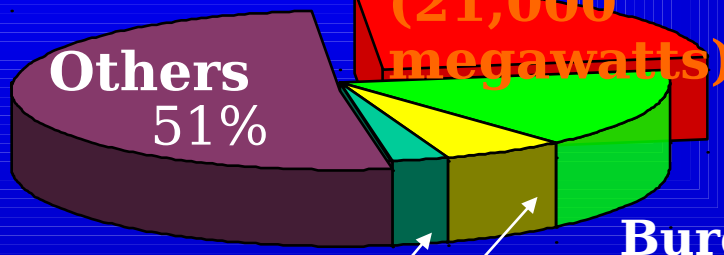
V. Sources of Information on Hydropower Benefits and Water Supply Reallocations

VI. QUESTIONS

US Sources of Electrical Power



The Corps has an $18 billion investment in hydropower facilities = Big Business!



Corps of Engineers
24%
(21,000 megawatts)

Others
51%

Bureau of Reclamation
16%

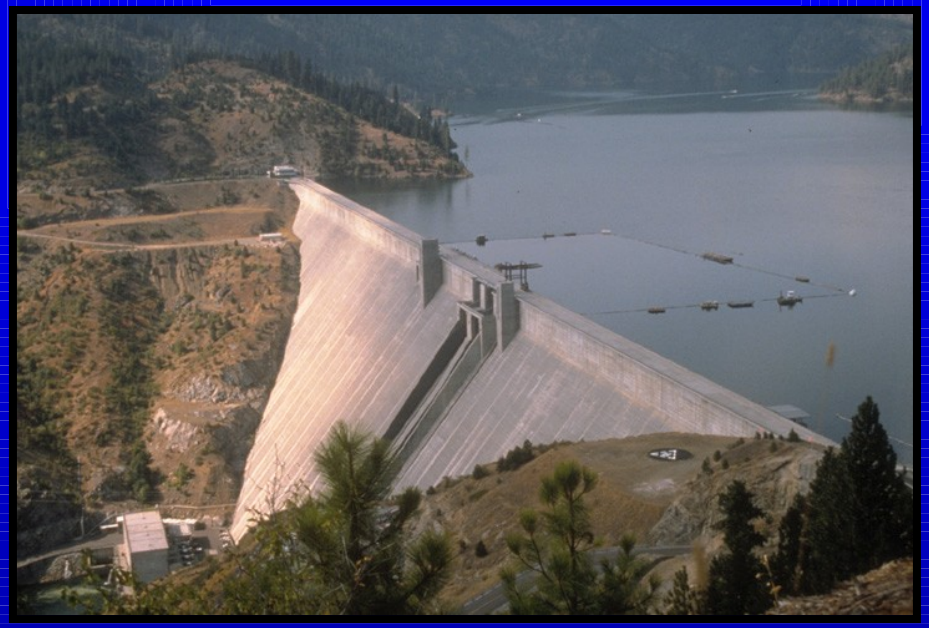
Commercial
3%

Tennessee Valley Authority 6%

US Army Corps of Engineers
Northwestern Division

Corps' Hydropower Capacity

- 76 hydropower plants
- Powerhouses with as many as 27 generating units
- 376 total generating units installed
- Generator capacities ranging from <1 MW to 220
- Total generating capacity of 21,000 MW



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VI. Questions

POWER BRANCH, Water Mgt. Division

BOLYVONG TANOVAN, CHIEF

KARLA TALENT, SECRETARY

OPERATIONAL PLANNING SECTION

- PATTIE ETZEL, HYDRAULIC ENGINEER
- RON MALMGREN, HYDRAULIC ENGINEER
- BARBARA MILLER, MATHEMATICIAN
- SONJA DODGE, ENGINEERING TECH
- SEAN ROSE, HYDRAULIC ENGINEER

HYDROPOWER ANALYSIS CENTER

- KAMAU SADIKI, TECHNICAL MANAG
- MICHAEL EGGE, HYDRAULIC ENGIN
- VACANT, ECONOMIST
- DINH QUAN, HYDRAULIC ENGINEER
- JOHN JOHANNIS, HYDRAULIC ENGIN
- RUSS DAVIDSON, GENERAL ENGINEE
- VACANT, ENGINEERING TECH

History of Hydropower Analysis Center

- Formed in 1948 as Hydropower Evaluation Section
- Primary Purpose was Performing Hydropower Economic Analysis to Determine Viability of Proposed Hydropower Developments in PNW
- Expanded to Perform Analysis Throughout U.S. and Foreign Countries
- Performed Studies for all Corps Districts and Foreign Countries such as China, South Korea, Nigeria and Others
- Established as an MCX in 1996

ER 1110-1-8158

- Designates Hydropower System Analysis MCX
- Mandates all USACE elements to coordinate with and use MCX services.
- Requires MSCs to monitor and certify appropriate use of MCXs

The Hydropower Analysis Center (MCX) Areas of Expertise:

Hydroelectric Design Center Support

- Major Powerplant Rehabilitation
- Generator Rewind Studies

Work for Districts and Other Offices

- Comprehensive River System Studies
- Cost Allocation & Water Supply Reallocation Studies
- Power Values
- Miscellaneous Studies

The Hydropower Analysis Center (MCX) Areas of Expertise:

(Continues ...)

Special Work Activities

- Develop Procedures for Evaluating Hydropower Benefits
- Risk Analysis of Major Compone
- Wrote Hydro Power Engineering Manual
- PEBCOM
- FERC Review

Cost Allocation And Water Supply Reallocation Studies:

- Analysis of the hydropower benefit component of cost allocation studies for multi-purpose water resource projects.
- Water storage reallocation studies to identify power benefits and revenue foregone with reallocation of storage for municipal and industrial water supply withdrawals.
- Recent storage reallocation studies includes White River Minimum Flow in SWL , Lake Greeson in MVK and John H. Kerr in SAW.

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VI. QUESTIONS

Definition of Common Terms

- **Energy** - The capability of doing work, expressed in terms of kilowatt-hours (kWh)
- 1 kWh of energy would be generated by a ten-foot cube of water falling 42.5 feet
- energy used by a typical household is

  175,000 kWh/year

Definition of Common Terms

- **<u>Capacity</u>** - the maximum amount of power that a generating unit or powerplant can deliver under a specified set of conditions

Definition of Common Terms

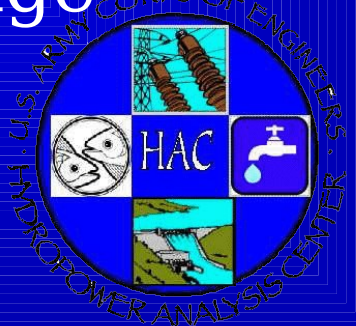
- **<u>Dependable Capacity</u>** - A measure of the amount of capacity that a project can reliably contribute towards meeting system peak demand.

Definition of Common Terms

- **Unit Power Values**
  - Energy Value - represent the fuel cost or variable cost of an alternative thermal generation resource that replaces the lost hydropower generation. Measured in units of $/MWh
  - Capacity Value - represents the capital cost, fixed O&M cost of the displaced thermal resource. Measured in units of $/kW-yr

Determination of Energy Impacts

- Formulation of alternatives (with & without storage reallocation)
- Simulation of alternatives to determine system generation for each alternative using a Sequential Streamflow Routing (SSR) model or historical data
- Difference in generation between alternatives with and without storage reallocation is determined



Determination of Energy Value and Energy Benefits Foregone

- Simulate the operation of the power system using an hourly system production cost (SPC) model “with” and “without” hydropower energy losses.
- The value of loss energy is determined by subtracting the SPC of the “without” from the “with” alternative. Then dividing the difference by the energy loss to obtain the energy value

Determination of Energy Value and Energy Benefits Foregone (continues...)

- This process repeated for at least five incremental future years and a unit average annual energy value is computed using a present-worth technique
- Energy benefits derived by multiplying the unit energy value by the difference in hydropower generation between the base and other alternati

Determination of Dependable Capacity Impacts

- Select appropriate methodology (usually Average Availability) for computing dependable capacity
- Coordinate with Power Marketing Agency (PMA) to determine the marketable capacity doing a critical period of adverse conditions.
- Simulate representative historical period with an SSR model, which includes a critical water year, to determine project capability

Determination of Dependable Capacity Impacts (continues…)

- Determine the number of hours on peak for each project by dividing the average weekly energy produced during the critical period by the PMA's marketable capacity
- Determine the actual supportable capacity for each year of the historical period for the "with" and "without" alternatives

Determination of Dependable Capacity (continues…)

- The average of the actual supportable capacity for each year in the historical period is the average dependable capacity
- The difference in average dependable capacity between the “with” and “without” alternative is the gain or loss in dependable capacity caused by the storage reallocation

Determination of Capacity Value and Capacity Benefits Foregone

- The capacity value represents the fixed cost associated with the increment of alternative thermal power plant capacity that would be displaced by the hydropower plant
- HAC computes the capacity value using a methodology developed by the Federal Energy Regulatory Commission (very detail process!!)
- Capacity benefits are computed by multiplying the capacity value by the gain/loss in dependable capacity

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VI. QUESTIONS

Typical Participants in Water Supply Power Impact Analysis

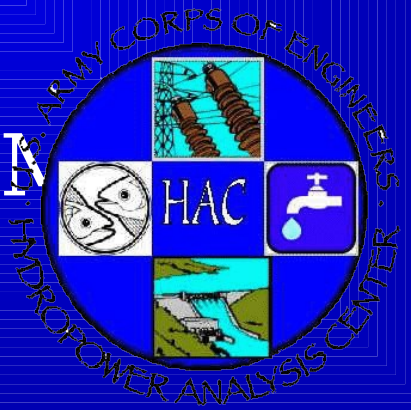
- Power Marketing Agency
  - Marketable Capacity
  - Energy and capacity rates for revenues foregone
- Division and/or District offices
  - Historical hydrologic/generation data
  - Water supply withdrawal amounts
  - Existing withdrawals
  - Project water control plan

Typical Participants in Water Supply Study (continues…)

- Project Personnel
  - Project operational information
- HAC
  - Benefits Foregone
  - Revenues Foregone
  - Credit to PMA

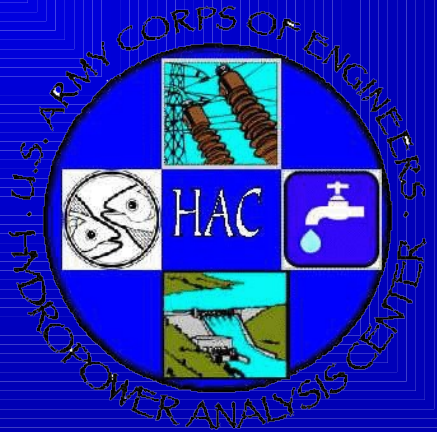
Sources of Data and Computer Models

- District Hydrology & Hydraulics office
- PMA, EIA
- SSRs: SUPER, HYSSR, HEC-5
- SPCs: PROSYM, POWRSYM, AURORA
- Capacity Value Spreadsheet M



Cost of Water Supply Reallocation to Hydropower

- ER1105-2-100 states that the cost of water supply reallocation to the customer be the highest of the following:
  - updated cost of storage in the Federal project (computed by District)
  - power benefits foregone
  - power revenues foregone
  - replacement cost of power



Power Benefits Foregone

- Power benefits foregone are divided into two components:
  - Lost energy benefits
    - based on the loss in generation at-site, upstream and downstream as a result of water being diverted for water supply rather than passing through the units
  - Lost capacity benefits
    - based on the loss of generating head due to lower post-withdrawal reservoir elevations
    - reduction in usability of the capacity due to inadequate energy to support the project's full capacity during low-flow periods

Power Revenues Foregone

- Represent the revenue reduction suffered by the regional PMA as a result of lost power sales due to the water supply withdrawal
- Based on current contractual rates of the PMA for energy and capacity

Replacement Cost of Power

- Replacement cost is a National Economic Development cost and therefore is a redundant cost relative to hydropower. NED power benefits foregone are based on the cost of the most likely thermal alternative to hydropower, which is the cost of replacement power.

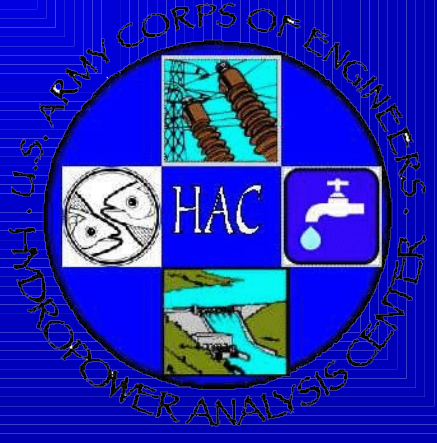
Credit to Power Marketing Agency

- If storage reallocation for water supply results in less hydropower for the PMA to deliver to customers, the PMA receives credit to offset additional cost they might incur, and to reduce their repayment obligation to the Federal treasury.

Credit to Power Marketing Agency (continues…)

- The first credit is intended to reduce the PMA's repayment obligation due to reduced revenues caused by the reallocation of storage away from hydropower.
- The second credit is intended to offset additional cost the PMA might incur if additional power must be purchased on the open power market to meet obligations under current power contracts.

FINALLY LUNCH TIME!!



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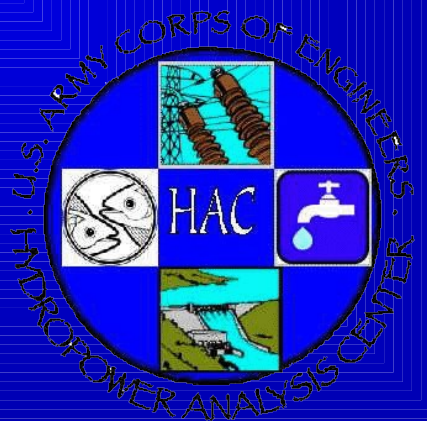
Water Supply Benefits Computation Process: An Illustrative Example

- Project Example
  - Allatoona Project, Etowah River, AL
- Compute Power Benefits Foregone
  - Capacity and Energy
- Compute Revenues Foregone
  - Capacity and Energy
- Discuss briefly credit to PMA

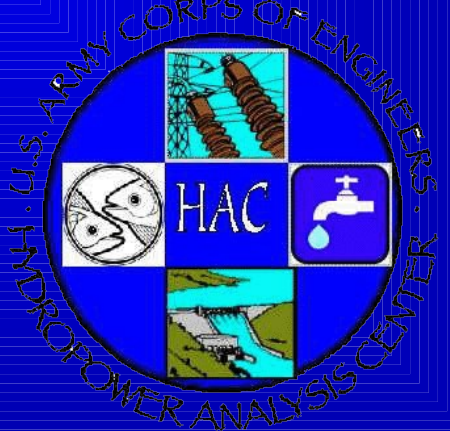
Illustrative Example
(continues…)

- Allatoona Project, Etowah River, AL
  - 671,000 AF total storage in reservoir
    285,000 Conservation, 303,000 Flood Control
    (difference is power head (inactive) storage)
  - 74 Mw of Installed Capacity
    2-36 MW; 1-2 MW (small unit used to pass project minimum streamflow)
- Authorized Purposes Recreation, Flood Control, Hydropower



Illustrative Example

- Problem Statement: A storage reallocation for water supply has been requested by the City of Cartersville, GA from Allatoona Lake on the Etowah River. The amount of withdrawal is planned to be 3.60 million gallons per day (MGD).



Illustrative Example
(continues...)

- The reallocation of storage away from hydropower will lower the power generating capability at Allatoona and at several downstream powerplants on the Alabama-Coosa river system. The reduction in power generation at the downstream projects will depend on where and how much of the proposed withdrawal is returned to the Etowah River. For this example, 80% of the withdrawal, or 2.88 MGD, is predicted to be returned immediately below Allatoona Lake. The remaining 20% of the withdrawal, or 0.72 MGD, was assumed to be consumptive loss.

Illustrative Example

(continues…)

From the Hydraulics & Hydrology staff, Mobile District:

Allatoona Lake Storage-Yield Relationship

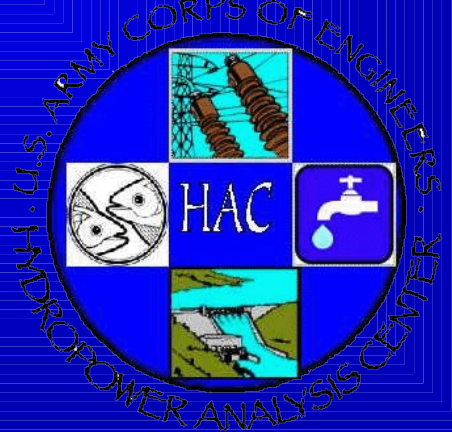
380.4 AF/MGD

Computed Storage Requirement

3.60 MGD x 380.4 AF/MGD = 1,369 AF

Storage reallocated to water supply for existing contracts

19,511 AF



Illustrative Example

(continues…)

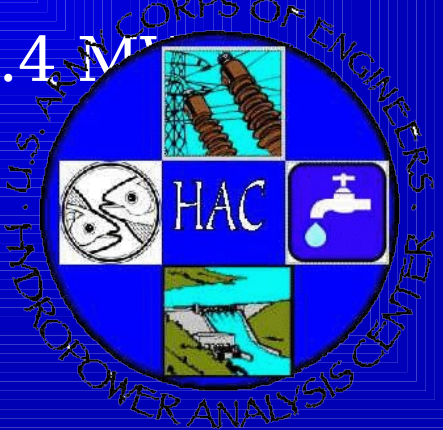
Computation of Energy Loss Due to Withdrawal

Power Equation: Avg. Ann. Energy Loss = [(Q)(h)(e)(t)] / [(11.81)(1000)]

Avg. Ann. Energy Loss = 513.4 MWh (Normally computed using a sequential streamflow routing model)

Downstream AAE Loss = 296.0 MWh (based on 0.72 MGD consumptive loss)

Total AAE Losses =513.3 + 296.0 = 809.4 MWh



Illustrative Example

(continues…)

Capacity Loss Due to Withdrawal

1981 avg. peak weekly energy = 955 – 420 = 535 MWh

(420 MWh is generated by minimum flow releases and is not considered peaking energy)

From the PMA: Marketable Capacity = 77 MW

Weekly hours on Peak = 535 MWh/77 MW = 7.0 hours

(The 7 hours criteria is used to compute dependable capacity for each year in period of record)

Average Annual Dep. Cap. Loss

Diff. between alternatives of the avg. 50-yr period of record dep. cap. = 24 kW

Illustrative Example
(continues...)

Power Benefits Foregone

- Levelized Energy Value ($/MWh) 28.53 (computed using PROSYM hourly model)
- Average Annual At-Site Energy Loss (MWh) 513.4 (computed using SSR model or power equation)
- Average Annual Downstream Energy Loss (MWh) 296.0
- Average Annual Loss in Energy Benefits $23,095
- Composite System Capacity Value ($/kW-yr) 61.48 (computed using Capacity Value Spreadsheet Model)
- Avg. Period of Record Loss in Dep. Cap. (kW) 24
- Average Annual Loss in Capacity Benefits $1,475
- Total Annual Benefits Foregone $24,570

Illustrative Example
(continues...)

Power Revenue Foregone

- SEPA Contractual Energy Rate ($/MWh) 7.21
- Average Annual At-Site Energy Loss (MWh) 513.4
  (same as power benefits foregone)
- Average Annual Downstream Energy Loss (MWh) 48.3
  (296 MWh minus non-Federal generation)
- Average Annual Loss in Energy Revenue $4,050
  (513.4 + 48.3) * 7.21
- SEPA Contractual Capacity Rate ($/kW-yr) 31.92
- 1981 Loss in Marketable Capacity (kW) 577
- Annual Loss in Capacity Revenue $18,418
- Total Annual Revenues Foregone $22,468

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Sources of Information

- Corps of Engineers Guidance
  - Water Supply Handbook
  - ER 1105-2-100 Planning Guidance Notebook
  - ER 1110-2-1701 Hydropower Manual
- HAC Website
  - http://www.nwd-wc.usace.army.mil/PB/index11.htm

Sources of Information (continues…)

- HAC Publications
  - Water Supply Reallocation, City of Hendersonville, John H. Kerr Reservoir, North Carolina: Report on Benefits Foregone (2003)
  - White River Minimum Flow Study, White River Projects (2003)
  - Power Benefits Foregone Due to Water Supply Withdrawals from White River Projects (1997)

QUESTIONS???